Report No. CG-D-29-95

EVALUATION OF AIRBORNE SLAR/FLAR CAPABILITY

Annex J of Cost and Operational Effectiveness Analysis for Selected International Ice Patrol Mission Alternatives

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FINAL REPORT

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16. Abstract

This report is Interim Report Volume 10 for the Cost and Operational Effectiveness Analysis for Ice Patrol Mission Analysis Study. Previous studies have provided a basis for estimating the probability of detection of icebergs by the AN/APS-135 SLAR radar. There is less of a basis for similar probabilities for the AN/APS-137 FLAR. There have been no studies or models which represent the joint effect of the radars. It is necessary to obtain a better estimate of performance from the FLAR radar. Models need to be developed to evaluate the search/image mode and determine the impact on POD due to intermittent looking. With that knowledge, integration with the existing or upgraded SLAR is possible with the expectation that the joint system POD curves can be developed and, ultimately, search levels may be reduced. The acquisition of the SLAR upgrade in the FY96 AC&I RCP is critical in order to maintain the existing high level of program performance. With an expected life of 14 years, the payback period is less than 4.5 years. The SLAR upgrade acquisition must also include a validation and verification component to develop new estimates of probability of detection for the "new" radar. A number of enhancements requiring follow on modeling efforts are possible. These include expanded track spacing (based on revised PODs), digital image enhancement, and full use of GPS with the Tactical Workstation to eliminated position ambiguity and enhance identification of detected targets.

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METRIC CONVERSION FACTORS

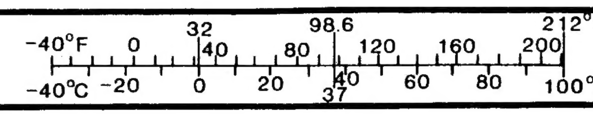
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



EVALUATION OF AIRBORNE SLAR/FLAR CAPABILITY

ABSTRACT

Previous studies have provided a basis for estimating the probability of detection of icebergs by the AN/APS-135 SLAR radar. There is less of a basis for similar probabilities for the AN/APS-137 FLAR. There have been no studies or models which represent the joint effect of the radars. It is necessary to obtain a better estimate of performance from the FLAR radar. Models need to be developed to evaluate the search/image mode and determine the impact on POD due to intermittent looking. With that knowledge, integration with the existing or upgraded SLAR is possible with the expectation that the joint system POD curves can be developed and, ultimately, search levels may be reduced. The acquisition of the SLAR upgrade in the FY96 AC&I RCP is critical in order to maintain the existing high level of program performance. With an expected life of 14 years, the payback period is less than 4.5 years. The SLAR upgrade acquisition must also include a validation and verification component to develop new estimates of probability of detection for the "new" radar. A number of enhancements requiring follow on modeling efforts are possible. These include expanded track spacing (based on revised PODs), digital image enhancement, and full use of GPS with the Tactical Workstation to eliminated position ambiguity and enhance identification of detected targets.

INTRODUCTION

Objective.

The primary source of iceberg surveillance information in the vicinity of the Limits of All Known Ice (LAKI) is the Commander, International Ice Patrol's Ice Reconnaissance Detachment (ICERECDET), deployed from St. John's, Newfoundland. The IIP ICERECDET presently uses a HC-130H aircraft equipped with a pair of Motorola AN/APS-135 Side Looking Airborne Radars (SLARs) (two antennas mounted in pods on either side of the fuselage, with common signal processing) and one nose-mounted Texas Instruments AN/APS-137(V) Forward Looking Airborne Radar (FLAR). The objective of the surveillance activity is to detect and classify icebergs and provide that information to the IIP for modeling predicted positions of icebergs and to develop appropriate warnings for the mariner. The purpose of this paper is to review the capability of the capability of the current SLAR/FLAR radar suite and the potential of the upgraded SLAR to meet the mission requirements.

CURRENT USAGE OF SURVEILLANCE RADARS

Search Planning and Coverage.

Details of search planning for ICERECDET patrols are covered in Armacost et al. (1994), Armacost (1994), and Armacost (1995a). In brief, approximately five sorties are performed during a nominal nine-day mission (every two weeks) to St. John's. Each sortie follows a preplanned flight path, the surface track of which is determined by the senior ICERECDET representative on the mission. Fight path planning is manual, with computer (PC) tool assistance. Because of generally restricted visibility, the altitude of the flight path is procedurally constrained to be above the 6000 ft. lower boundary of controlled airspace, and is normally at or near this limit. The sorties of a single mission collectively supply coverage of a swath following the boundaries of the (model predicted) Limits of All Known Ice (LAKI), and extending, in searched surface area, from about 25 nm beyond this line to as far inside the line as can be covered for the combined sorties while satisfying fuel constraints.

Search Patterns and Probability of Detection.

Search patterns are based on the characteristics of the AN/APS-135 using a parallel search pattern with a track spacing of 25 nm. The SLAR range scale is set at 27 nm so that the SLAR coverage is nearly 200%. The purpose of the 200% coverage is to try to ensure that small icebergs and growlers are detected and to provide a means of determining target movement and aid in identification of a radar target as an iceberg. Where possible, tracks are oriented in a N-S or E-W direction (or at least cardinal headings) to facilitate georegistration of the sightings which is accomplished manually on the gridded dry film processed by the SLAR. Most search patterns are less regular in practice because of the need to cover particular areas of the LAKI.

AN/APS-135 SLAR Probability of Detection.

There have been a number of experiments over the years (e.g., BERGSEARCH '84--Rossiter et al., 1985; Robe et al., 1985; Alfultis and Osmer, 1988) that have permitted reasonable estimates of the probability of detection of various types of icebergs by the AN/APS-135 SLAR. Probability of detection is a function of the inherent electronic design of the radar, reflectivity of the icebergs, the limitations associated with the dry film processor, and the ability of the trained operators to interpret the dry film images. The design characteristics of the radar are included in Armacost et al. (1994) and Armacost (1995a). Jacob (1995) has discussed the technical capability of the radar in detail. Those discussions are not repeated here. Armacost (1995a) synthesized the several experimental evaluations to attempt to develop reasonable estimates of the probability of detection. The experiments and evaluations suggested that the within the current operating scenario of a 25 mile track spacing, the radar detection followed a definite range law with a zero POD for a 4 mile wide band directly under the aircraft. The results from the different studies are summarized in Table 1.

Table 1. AN/APS-135 SLAR Ice Target Data Summary.

TARGET TYPE	BERGSEARCH 84 8000 ft/25 km	Robe et al. 1985 8000 ft/50 km	Alfultis and Osmer, 1988 4000-10,000 ft/50 km
Large Icebergs			17/17 (1.00)
Medium Icebergs		7/7 (1.00)	132/132 (1.00)
Small icebergs	11/12 (0.92)*	34/39 (0.87)	47/48 (0.98)
Growlers	19/48 (0.40)* **	10/11 (0.91)	

*Slightly different classification by size
**Includes Bergy bits and Growlers

These results are combined in Table 2.

Table 2. AN/APS-135 SLAR Ice Target Estimated System POD.

TARGET TYPE	Estimated System POD
Large Icebergs	17/17 (1.00)
Medium Icebergs	139/139 (1.00)
Small Icebergs	92/99 (0.93)
Growlers	29/59 (0.49)

Note that these results are for detections with alerted operators. As such, these represent system capabilities. Probabilities of identification and classification degrade these initial probabilities as illustrated in Armacost (1995a).

AN/APS-137 SLAR Probability of Detection.

There have been two evaluations of the AN/APS-137 FLAR system have been conducted to examine iceberg detection. The 1991 AN/APS-137 FLAR evaluation (Ezman *et al.* 1993) involved HC-130 flights over a four day period and utilized altitudes and search ranges on either side of current FLAR operating conditions . The report of the second evaluation (Trivers and Murphy, in preparation) is not yet available for review. Over all flight altitudes and range settings (13 flights) the FLAR operators detected 48 out of 54 (POD = 0.89) actual iceberg targets, and correctly identified 39 of 48 (adjusted POD = 0.72) as icebergs. The data included in the report does not include the lateral range of detection. However, it could be estimated from the target positions given in the report. Enclosure 1 to the report suggests that a medium iceberg is detectable at the outer limits of the 8, 16, and 32 nm range scales. The 54 detection opportunities shown on the ground truth figures included 3 small, 44 medium, and 7 large icebergs. The report does not analyze detection by target type as was done in the SLAR analyses. Enclosure 2 to the report also notes that 2/3 of the screen was obscured with sea clutter when operating in the 32 nm scale. The report recommends operating on the 64 nm scale which has been adopted by IIP.

Data in the report are difficult to interpret. A cursory examination suggests that the probability of detection may actually be lower than that indicated above. The iceberg

searches in this analysis were conducted using the search mode. Parallel analyses of liferaft detection capabilities were conducted using periscope mode at lower altitudes. The 1993 analysis indicated that the best liferaft detection performance for FLAR was between 350° and 010°R and that performance dropped off significantly at relative bearings greater than ± 045°R. At ± 010°R, the lateral range on the 64 nm scale would be 11.1 nm; at ± 045°R, the lateral range on the 64 nm scale would be 42.3 nm. At this point, there is not enough information available to estimate whether the definite range law would apply, and if so, what is the appropriate lateral range at which detection will not occur?

The figures depicting the FLAR patrols and sightings indicate a significantly larger number of radar targets in the area than known icebergs and ships. It is suggested that a possible source of this discrepancy is the use of INS navigation and a repeat sighting on an adjacent search leg may also be identified as a separate target. Because of the nature of the ground truth, the POD results should only be used for large or medium icebergs.

Descriptions of the radar capability and design characteristics are included in Armacost et al. (1994) and Armacost (1994). Development of probabilities of detection is included in Armacost (1995a) and a description of technical performance of the radar is included in Jacob (1995).

SLAR/FLAR CAPABILITY

Joint capabilities.

The probabilities presented above were developed for the two radars separately. There have been no experiments to evaluate the joint effect of the two radars, nor have there been any models to estimate the joint effects. Preliminary conclusions from the several studies have indicated that the FLAR is not a surveillance replacement for the SLAR. Present practice uses the FLAR to enhance the classification capability of the SLAR. A search effectiveness model is developed in Armacost (1995a) for SLAR alone and FLAR alone. That model could also be applied if the joint POD were known. The current search effectiveness with the existing system is described in Table 3.

Table 3. System Effectiveness for SLAR Searches.

TARGET TYPE	4 leg search	6 leg search
Large iceberg	1.00	1.00
Medium iceberg	1.00	1.00
Small iceberg	0.97	0.97
Growlers	0.63	0.66

Given that the SLAR or FLAR system presents a radar target, it is important to the IIP to know whether the target is an iceberg or a ship. Present operation of the SLAR

utilizes 200% coverage of a significant portion of the search region to minimize the probability of missing any icebergs in the area in the vicinity of the LAKI and to provide a mechanism for classifying targets as icebergs based on estimated movement. The SLAR operators have developed considerable expertise in recognizing icebergs. With the 200% coverage, operators evaluate the position of the targets on the second pass and determine if there is any movement. The result of this manual process determines whether the target is classified as an iceberg.

The classification processes using the SLAR and the FLAR are significantly different. For the SLAR, classification is made by determining that the target has relatively little movement (misclassifications of fishing vessels as icebergs are possible). During this process, except for operator attention, the detection process continues and images are presented on the dry film. With the FLAR, however, classification is accomplished in the imaging mode which requires a lock-on to the target. When this occurs, no detection is taking place. At a patrol speed of 250 kt, each minute spent imaging results in 4.2 nm of track not being searched. Using the FLAR as a sole detection device would severely limit its opportunity for imaging and identification/ classification of the targets.

FLAR Probability Model.

The development of lateral range curves for detection presume continuous looking. The use of FLAR alone with interruptions for imaging results in an intermittent looking search pattern that results in a different (lower) probability of detection. The amount of allowable imaging is inversely proportional to the target density in order to achieve some minimum level of POD. At indicated above, no such model has been developed for IIP FLAR operations. Search planning uses 200% SLAR coverage to achieve an acceptable probability of detection, identification and classification. If the POD from the FLAR search were known, SLAR coverage could be reduced while maintaining the same overall POD by using sensor fusion models while maintaining acceptable classification levels. Any efforts to develop "optimal" search plans should incorporate POD information from FLAR and will require this information. This represents a separate development project.

AN/APS-135 SLAR Upgrade.

Technological obsolescence.

The AN/APS-135 SLAR has been classified as technologically obsolescent due to the existing dry film processor technology used to represent the images. The dry film processor heads are no longer in production and spare parts are difficult to obtain. Several partial spares are available at Air Station Elizabeth City. A limited number of boxes of film (which must be kept refrigerated) exist in the world and the cost to manufacture more film is prohibitive. Current estimates are that the SLAR will be maintainable through the 1996 ice season.

Synthetic Aperture Radar (SAR) option.

One possibility is replacing the SLAR with another radar. Various SAR systems were considered and alternative sensor systems were evaluated. Jacob (1995) contains a detailed evaluation of SAR systems and their applicability for iceberg detection. Various platforms were also evaluated (e.g., satellite, airborne, unmanned aerial vehicle.) All of these systems tend to be very costly and the availability of a digital upgrade for the AN/APS-135 SLAR at a relatively modest cost as described below precluded a need to examine further alternatives.

FY96 AC&I SLAR Upgrade RCP.

AC&I Resource Change Proposal (RCP No. 610) for FY 1996 provides for a "C-130 Side Looking Airborne Radar (SLAR) Upgrade" and seeks funding in the amount of $2.1 million. to replace the existing dry film processor with a digital processor. Specifically, the SLAR Upgrade will replace the radar signal processor, image processor, radar data recorder, radar set control, and CRT display. The upgrade provides imagery and data downlink capability for real time imagery transmission to operational commanders. The SLAR upgrade is identical to the ongoing upgrade of the AN-APS-131 SLAR installed on the HU-25 aircraft. RCP No. 610 installs the upgrade on two HC-130 aircraft and provides for ground stations capable of real time receiving, transmitting, and replaying all SLAR imagery. The technology uses open system architecture for hardware and software design.

The upgrade is expected to carry the sensor through 2010. The original system was acquired in 1977. With an expected life of fourteen years for the upgraded system, amortized acquisition costs amount to $150,000 per year, or the equivalent of about 35 flight hours at present standard rates. The upgraded system provides opportunities for significant cost reductions that will more than cover the acquisition costs.

A copy of the RCP is included in Appendix I. Details on what is included are weak. One critical aspect of the SLR upgrade is the development of performance parameters. The RCP should include a validation and verification (V&V) section that will develop a sound basis for estimating the probability of detection of various icebergs, similar to Table 1. It is important to recognize that all of the old data is no longer valid with the essentially new system. Either that experimentation should be included in the RCP or a new RCP be prepared to conduct the V&V.

System Effectiveness Improvement and Cost Reductions.

Revised search patterns.

The present flight procedure uses a 25 nm track spacing with the SLAR operating on the 27 nm range. The primary purpose for this setting is to prevent the film images

from becoming too degraded at the next larger scale setting and adversely affect their interpretation. The radar itself has an effective range of 80 nm. With digital recording, all images are accessible for analysis. At extended ranges, it will be necessary to develop appropriate lateral range curves in order to estimate probabilities of detection. With installed GPS, a 200% coverage will eliminate any ambiguities due to drift and track error using the INS and dry film and will permit reliable identification of stationary targets which can then be imaged by the FLAR for classification purposes. Suppose a doubling of track spacing to 54 nm with a continued 200% coverage was able to meet present performance requirements. (This is a reasonable expectation.) Further, assume that one-third of the patrol hours are enroute hours and two-thirds were active search hours (approximately 270 hours in 1994). Doubling the track spacing will potentially reduce the search time by half, saving 135 flight hours (equivalent to $573,000 at the standard rate). Using the CGFINCEN 1994 IIP aircraft costs (see Table 5 in Armacost, 1995b) of $3450 per hour, the savings amount to $465,000, more than a three fold positive B/C ratio.

RCP failure consequences.

The previous IIP analyses have concluded that the AN/APS-137 FLAR is not a suitable replacement for the SLAR. The various analyses conducted in this report support that conclusion. Failure of the SLAR would force reliance on the FLAR and increased visual observation. Because of the reduced track spacing and the need for visual observation, IIP has estimated that an additional 2.3 sorties (14 flight hours) would be required for each ICERECDET. With an average of 15 ICERECDETs per season, this translates to an additional 210 flight hours. Using the standard cost of $4,244 per flight hour (Armacost, 1995b, Table 1), the additional annual operating cost would be over $890,000. Given the state of knowledge of FLAR performance, it is not possible to demonstrate that this will achieve the same level of performance.

Use of Global Positioning System (GPS).

It is expected that the digital upgrade to the AN/APS-135 SLAR along with the use of GPS will improve the georegistration, thereby assisting the classification process, and will permit digital enhancing to assist the operator in identifying targets. It is expected that the upgrade will permit the system to operate at the effectiveness shown in Table 3. The Airborne Tactical Workstation described in Armacost (1995c) should have the capability to incorporate a checking algorithm that compares positions and makes a preliminary identification assessment.

Digital image enhancement..

It is possible that system effectiveness could be improved by means of digital enhancement. The digital file is available and with known image characteristics of icebergs to be recorded under experimental conditions, pattern recognition and matching algorithms could be used to enhance images to permit better identification. It is not clear whether equipment to accomplish this task is included in RCP No. 610.

SUMMARY AND CONCLUSIONS

There are a number of actions to be taken that will improve the Coast Guard surveillance. It is necessary to obtain a better estimate of performance from the FLAR radar. Models need to be developed to evaluate the search/image mode and determine the impact on POD due to intermittent looking. With that knowledge, integration with the existing or upgraded SLAR is possible with the expectation that search levels may be reduced. The acquisition of the SLAR upgrade is critical in order to maintain the existing high level of program performance. With an expected life of 14 years, the payback period is less than 4.5 years for the planned upgrade in the FY96 budget. The SLAR upgrade acquisition must also include a validation and verification component to develop new estimates of probability of detection for the "new" radar. A number of enhancements requiring follow on modeling efforts are possible. These include expanded track spacing (based on revised PODs), digital image enhancement, and full use of GPS with the Tactical Workstation to eliminated position ambiguity and enhance identification of detected targets.

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Appendix I. FY96 AN/APS-135 SLAR Upgrade Resource Change Proposal

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AC & I RESOURCE CHANGE PROPOSAL - PART I

Program NIO

RCP NO. 610 | TITLE C-130 SIDE LOOKING AIRBORNE RADAR (SLAR) UPGRADE | EXT: 7-0952

96 | QTR: 4 | POC: LCDR C W LILLIE

PURPOSE Provide funding to import proven AIREYE technology into 2 C-130 SLAR sensor equipped aircraft located at CGAS Elizabeth City. Upgraded SLAR system will ensure our long range international response resource is fully capable and ready to meet International Ice Patrol (IIP) and Marine Environmental Protection (MEP) mission requirements into the next decade.

NET RESOURCE CHANGES REQUIRED	BUDGET YEAR AC & I ($000)	TOTAL PERSONNEL * MIL	CIV
ALTERNATIVE A	2100	1	0
ALTERNATIVE B			
ALTERNATIVE C			

* BASED ON END OF YEAR * SEE PART III FOR DETAILS ON ALTERNATIVE A

PROGRAM / SUPPORT MANAGERS ENDORSEMENTS:

PROGRAM	INITIALS	PROGRAM	INITIALS	PROGRAM	INITIALS
G-EAE	[initials]	G-MEP	[initials]	G-NIO	[initials]

DESCRIPTION OF PROBLEM OR GOAL C-130 SLAR aircraft will be unable to operate at required program level [IIP (NIO) and MEP operations] due to the lack of production replacement sensor equipment, obsolescence of existing sensor equipment, and 1996 phase out of the SLAR film under DoD contract. Available logistical support for entire SLAR sensor management system, and some parts of core sensors, is nearly exhausted. This project will import proven AIREYE technology to modernize C-130 SLAR equipment.

CRITERIA Insure operations at the required program level are possible into the next decade. Replace the radar signal processor, image processor, radar data recorder, radar set control, and CRT display. Project will provide a high resolution monitor of sufficient quality for real time use and eliminate the specialized film requirement that is no longer in production (DoD discontinued production of film and excessed remaining stock for foreign military sales.)

IMPACT OF DENIAL C-130 SLAR sensor system will not meet IIP mission requirements after 1996. Current SLAR system represents first generation/one-of-a-kind technology. Without upgrade/modernization, C-130 SLAR equipment will not continue to operate due to lack of replacement parts/equipment, and obsolescence of existing equipment. All-weather ice observation capability will be lost. Real time/on-scene SLAR data from data link will not be available to operational commander to support MARPOL & Ice Ops.

APPROPRIATION HISTORY

PROGRAM	YEAR	AMOUNT ($000)
C-130 SLAR Installation (AC&I RCP 1022)	1977	856
C-130 SLAR Follow-on (OE RCP 52.02)	1978	92

FOR NEW PROJECTS EXCEEDING $20M IN TOTAL PROJECT COSTS:

HAS THIS BEEN NOMINATED AS A MAJOR ACQUISITION? No

HAS A MISSION NEEDS STATEMENT BEEN PREPARED? No

FOR NEW AUTOMATED INFORMATION SYSTEM ACQUISITIONS:

WHAT IS THE STATUS OF THE AIS PROPOSAL?

HAS A REQUIREMENTS ANALYSIS BEEN PERFORMED? No

IS ONE PLANNED? No IF SO WHEN? ______

FOR SHORE PROJECTS WITHOUT AN APPROVED PPR:

STATUS OF PLANNING DOCUMENTS: PP? PPR?

PM: G. R. MCGUFFIN, CAPT | PD: R. A. APPELBAUM, RADM | Date 08 APR 94

CPA-RCP.ac&i.pt1_2/8/

ANALYSIS	AC & I RESOURCE CHANGE PROPOSAL - PART II	ALTERNATIVE A
RCP NO. 610	TITLE C-130 SIDE LOOKING AIRBORNE RADAR (SLAR) UPGRADE	

DESCRIPTION Provides funding to import proven AIREYE technology for upgrade of existing C-130 SLAR systems. Supportable, upgraded sensor systems will support IIP and MEP missions, maintaining our national/international response agreements. Upgrades/replaces SLAR film reader/printer and monitor with an upgraded image processor, display, and storage unit. Project provides data down link capability to operational commander from SLAR equipped C-130 aircraft. Downlink allows for timely and efficient delivery of SLAR imagery to operational commander.

TOTAL PROJECT REQUIREMENTS BY YEAR (BASED ON EOY)

BY+1			BY+2			BY+3			BY+4			TOTAL PROJECT COST
($000)	MIL	CIV	($000)	MIL	CIV	($000)	MIL	CIV	($000)	MIL	CIV	($000)
0	1	0	0	1	0	0	0	0	0	0	0	2,100

IMPACT ON OE & R&D NON-PERSONNEL FUNDING ($000):

	BY-1	BY	BY+1	BY+2	BY+3	BY+4
R&D						
OE (+ or -)						

RECURRING IMPACT ON OE PERSONNEL (PRIMARY UNIT)

	OFF	WAR	ENL	CIV	TOTAL
CURRENT	0	0	0	0	
PLANNED					

YEAR PERSONNEL IMPACT OCCURS: 0

IMPACT ON SUPPORT ACTIVITIES (SUPCENS, TRAINING UNITS, ETC.):
DESCRIBE AND, IF POSSIBLE, QUANTIFY ANY IMPACTS. Provides standardized SLAR sensor system for C-130 and HU-25B AIREYE aircraft. Creates efficiencies in parts and logistics support. Support and maintenance personnel will not require training on different equipment. Operators will be able to standardize procedures and training can be combined.

BENEFITS EXPECTED Upgraded C-130 SLAR system provides required long range, all-weather IIP and MEP response into the next decade. The upgraded system increases our ice patrol capabilities and standardizes sensor systems. Upgraded system eliminates need for expensive and out of production SLAR film. Acquisition, support and training costs will be minimized as the HU-25B AIREYE and HC-130 SLAR systems will use like technology and equipment. Provides real time data down link capability from long range aircraft flown on IIP and MEP missions. Enhances synergy that already exists between C-130 facility and National Strike Force mission. Downlink permits non-stop surveillance and timely transmission of on-scene conditions. Service life of a valuable resource will be extended.

BASIS OF COST ESTIMATES G-OAV, G-EAE, Motorola Government Electronics Group, Scottsdale, AZ.

Software/NRE integration	580K
SLAR upgrade (2 ship sets plus spare equip)	1,260K
GSE/test equipment	100K
Downlink Equipment/ integration	160K
Total	2,100K

EXPECTED PROGRAM CONTRIBUTION OF RESOURCE ALLOCATION

PROGRAM		PROGRAM		PROGRAM		PROGRAM		PROGRAM		PROGRAM		
G-NIO	60 %	G-MEP	40 %		%		%		%		%	100%

AC & I RESOURCE CHANGE PROPOSAL - III (FOR ALTERNATIVE A ONLY)

RCP NO. 610	TITLE: C-130 SLAR UPGRADE	PROGRAM NIO	BY: 96	POC: LCDR C.W. LILLIE	EXT: 7-0952

PROJECT C-130 SLAR UPGRADE PROJECT

BY REQUEST OPFAC	UNIT NAME	GRADE	JOB TITLE	START DATE	TERM DATE
98-70098	AERONAUTICAL ENGINEERING (G-EAE)	AVI4	C-130 SLAR UPGRADE PROJECT- PROJECT TEAM LEADER, AC&I TERM	7/01/96	9/01/98

REQUESTED CHANGES FOR BY:	MIL	CIV
ADD		1
DELETE		
EXTEND		
CHANGE		

SUMMARY: OFF WAR 1 ENL GS/GM WG TOTAL 1

ANTICIPATED TOTALS IN THE OUTYEARS:

	BY+1	BY+2	BY+3	BY+4
OFF				
WAR	1	1		
ENL				
GS/GM				
WG				
TOTAL	1	1		

JUSTIFICATION FOR BY PERSONNEL REQUEST Coordinate integration, procurement, and installation of SLAR upgrade aboard Coast Guard C-130 aircraft. Provide technical assistance and direction. Maintain liaison with the manufacturer, contract field team (installation). Execution of this project requires position establishment as soon as funds are available to insure that this important sensor equipment is installed.

IMPACT OF DENIAL OF ALL OR PART OF THIS PERSONNEL REQUEST A coordinated integration, procurement, and installation of C-130 SLAR sensor system will not be accomplished. Technical assistance and direction will not be provided.

AC & I RESOURCE CHANGE PROPOSAL - . III (FOR ALTERNATIVE A ONLY)

RCP NO. 610	TITLE: C-130 SLAR UPGRADE	PROGRAM NIO	BY: 96	POC: LCDR C.W. LILLIE	EXT:

PROJECT NONE - NEW START

BY - 2 BASELINE END OF YEAR FUNDING

OPFAC	UNIT NAME	GRADE	BCN / PCN	JOB TITLE	TERM DATE

SUMMARY: OFF WAR ENL GS / GM WG TOTAL

BY - 1 BASELINE (EOY)

OPFAC	UNIT NAME	GRADE	BCN / PCN	JOB TITLE	TERM DATE

ANTICIPATED CHAGES FOR BY - 1:	MIL	CIV
ADD		
DELETE		
EXTEND		
CHANGE		

SUMMARY: OFF WAR ENL GS / GM WG TOTAL

HC-130 SLAR UPGRADE AC&I PROJECT FORECAST

I. Funding/Obligation Plan ($FY96)

YEARS
(Total Program Span--BY/Future through BY+1)

	FY95 ($000)
Funds Appropriated or planned in BY through BY+1	2,100
Less Reprogrammings	0
Net Program Funds Available	2,100
Less: Obligations/commitments	
APS-135 (SLAR) Upgrade (signal processor, image processor, color CRT, and radar data recorder) (includes 1 spare set of production hardware)	1,260
SLAR Upgrade Non-Recurring Engineering/software integ	580
GSE/Test Equipment/ Hot Mock-up	100
Ground Station hardware, including datalink	160
Subtotal: Obligations/ Commitments	2,100
BALANCE (shortfall/ carryover)	0

II. Installation Schedule

	FY96
HC-130 SLAR Upgrades	2

Total- 2 Aircraft and 2 Systems

1996

C-130 SIDE LOOKING AIRBORNE RADAR (SLAR) UPGRADE VARIOUS $2,100,000

Reason for Request: To fund the import of proven AIREYE technology to upgrade the HC-130 Side Locking Airborne Radar (SLAR) system. Upgrade 2 SLAR sensor systems and modify 2 HC-130 aircraft to accept the upgradeThis will maintain Coast Guard capability for airborne International Ice Patrol (IIP) monitoring and expand support for marine environmental surveillance missions into the next decade.

Description of Problem or Need: SLAR is an all-weather aerial surveillance information gathering and recording system installed in HC-130 aircraft capable of detecting, mapping and tracking variety of surface targets including ice flows, icebergs and oil spills. SLAR accomplishes detection through the "calming" effect that floating objects or substances have on surface wave action. The area of calm water reflects less radar energy than normal surface waves or ripples and is detectable by the SLAR. Without modernization, the HC-130 SLAR sensor aircraft will be unable to operate at the required mission level due to lack of production replacement sensor equipment and obsolescence of existing recording, processing and control equipment. Massive cannibalizing of existing equipment has avoided system failure.Available logistical support for the SLAR sensor data management system, and some parts of the core sensors, is nearly exhaustedFor example, current SLAR system records images on a specialized, thermal film.The thermal film is no longer produced and will be phased out of the DoD supply system by 1996. Also, current SLAR system is first generation/one-of-a-kind 1970's technology and requires the aircraft to land and physically deliver thermal film to the operational commander.

Description of Solution: This project will standardize the Coast Guard SLAR equipped aircraft by upgrading the HC-130 SLAR to the HU-25B AIREYE standardThe project will replace outdated and obsolete sensor systems. The project includes replacement of the current SLAR film reader/printer and monitor with an upgraded image processor, display, and storage unit. Imagery and data down link capability will be added for real time imagery transmission to operational commanders. When this project is complete, a total of 2 SLAR systems and 2 HC-130 aircraft will be modified, including ground stations capable of real time receiving, transmitting and replaying all SLAR imagery.The upgraded sensor anagement system will import proven AIREYE off-the-shelf technology utilizing open system architecture for hardware ıd software design. This will minimize development and production costs, and contain future maintenance and upgrade expenses.

Benefits: Approval of this project will improve the performance and extend the service life of a proven, valuable sensor system to approximately year 2010. The HC-130 all-weather SLAR sensor system has enabled the Coast Guard to reduce dedicated flight hours for International Ice Patrol and not to depend solely on visual aerial reconnaissance to locate and track surface targets. An upgraded and supported SLAR system insures availability of modern technology for long range ice patrol and marine environmental protection operations and maintains our national and international response agreements. Moreover, the upgraded system is capable of downlinking "real time" on-scene information to operational commander thus eliminating need to land the aircraft and physically deliver the developed thermal film.Operational commanders will have timely imagery to properly evaluate on-scene conditions and effectively deploy appropriate resources.

IMPACTS ON OPERATIONS AND/OR MAINTENANCE STAFFING
(NON AC&I FUNDED)

	OFF	WRNT	ENL	CIV	TOTAL
CURRENT........NOT APPLICABLE					
PLANNED........NOT APPLICABLE					

APPROPRIATION HISTORY

PROGRAM	YEAR	AMOUNT($000)
HC-130 SLAR ACQUISITION	1977	856

SUMMARY ($000)

AMOUNT OF THIS REQUEST....................	2,100
ESTIMATED FUTURE COST NEXT 4 YEARS - THIS PROJECT....................	---
ESTIMATED FUTURE COST NEXT 4 YEARS - THIS FACILITY....................	---

COST ESTIMATE OF WORK TO BE FUNDED THIS YEAR

ITEM NO.		MEASURE	ESTIMATED COST QTY	($000)
1.	Sofware/NRE integration	EA	1	580
2.	SLAR sensor replacement/APS-135 upgrade	EA	2	1,260
3.	GSE/Test equipment	EA	1	100
4.	Downlink Equipment/Integration	EA	2	160
			TOTAL	2,100

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U.S. Department of Transportation

United States Coast Guard

Memorandum

Subject: RCP SUPPORT: UPGRADE ON AN/APS-135 SLAR

Date: JAN 31 1994
16170

Reply to: G-NIO 7-1460
Attn. of: LCDR GARRETT

From: Chief, Ice Operations Division

To: Chief, Aeronautical Engineering Division

Ref: (a) RCP 95-610: C-130 IIP UPGRADE FOR AN/APS-135 SLAR

1. I strongly support the proposed upgrades to the AN/APS-135 Side Looking Radar (SLAR) aboard the Air Station Elizabeth City HC-130s. Without the upgrade the SLAR system aboard HC-130s will become unsupportable due to the unavailabilty of spare parts and consumables. This will negatively impact the cost effective performance of the International Ice Patrol and Ice Breaker missions.

2. My support for the HC-130 SLAR upgrade is based on the following Ice Operations Program support requirements:

a. Airframe: The extensive area covered by IIP operations and remote operating areas of the polar icebreakers require the range of the HC-130 which is not attainable with any other current CG aircraft.

b. Sensor: SLAR provides a long-range, cloud penetrating ice reconnaissance sensor for use by the IIP to detect and distinguish radar contacts to verify iceberg positions. Upon the loss of the SLAR system, the IIP mission would revert to visual reconnaissance, with a significant increase in required flight hours, due to human visibility limitations. The SLAR is also more effective than observers in distinguishing ice edges and concentrations for optimal icebreaker track routing. In addition SLAR imagery provides a record which can be used in conjunction with other remote sensor information to enhance ice analyses and forecasts.

LOSURE(1)

c. Downlinks: Direct icebreaker support is been limited by the inability of the present film system to downlink images to the icebreaker. Current film handling procedures require a minimum of several days for data analysis and transmission. The final analysis product is not a RADAR image. The digital upgrade would overcome this deficiency. It will allow actual RADAR images to be immediately and directly downlinked to the icebreakers. This is a first step in the integration of SLAR into the FY95 proposed ice navigation systems, which will overlay ice information on an ECDIS system.

d. Hour Requirements: The loss of SLAR would increase the HC-130 hours required by IIP at a time when other emerging Ice Operations requirements are also demanding HC-130 support. IIP has routinely required over 500 hours of HC-130 aircraft time in support of their mission, and aircraft hours will increase with the loss of SLAR. Arctic and Great Lakes ice observations which have not routinely been programmed are being proposed by the US Navy/NOAA Joint Ice Center (JIC) and the Canadian Coast Guard. Increasing support to the US Navy/NOAA Joint Ice Center is expected once the CG becomes a third partner in a renamed National Ice Center.

3. The continued reliability and availability of the APS-135 radar is affected by both film availability and radar repair parts. The SLAR Support Manager, G-EAE is negotiating with the US Army to obtain control over 40 cases of film to meet expected needs through FY98. However, this film must be stored frozen and the dry-film processor is increasingly difficult and expensive to support due to non-production of parts by the manufacturer. Existing spares are continually reworked with expensive custom-ordered parts. Reliability of the radar after FY96 will be severely impaired.

4. Other available options:

a. Airborne Radar (None): The SLAR is the best available iceberg reconnaissance RADAR. IIP investigated the usefulness of the AN/APS-137 radar as a replacement of AN/APS-135 during operations last season. The comparison suggested the APS-137 should not be viewed as a SLAR replacement, but rather as a complementary system. The APS-135 SLAR is a detection radar with extensive coverage and excellent resolution. The APS-137 provides a much narrower view with better target discrimination. The side-by-side arrangement of the two radar displays provides the IIP ice observer with improved effectiveness to search the ocean for contacts, then discriminate between vessels and icebergs for mission purposes.

16170

JAN 31 1994

Subj: RCP SUPPORT: UPGRADE ON AN/APS-135 SLAR

b. Satellite Radar Systems: The number of satellite-borne radars are increasing. Two , the European Remote Sensing Satellite (ERS-1) and the Japanese Earth Resources Satellite (JERS-1) are currently operational and the Canadian RADARSAT is scheduled for a 1995 launch. Unquestionably, these radars will be useful in IIP mission support, however, they should initially be viewed as complementary systems to the aircraft-based radars. Their lower resolution, restricted data availability, long data processing times at specialized facilities and high data acquisition and processing costs will limit their effectiveness in the near future.

A. F. WALKER

Copy: (G-CPA)
(G-OAV)
(G-MEP)

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U.S. Department of Transportation

United States Coast Guard

Memorandum

Subject: SLAR UPGRADE COST ESTIMATE FOR FY96 RCP COST ESTIMATE

Date: 1 APR 94
43A079

Reply to: G-EAE-43A
Attn. of: CWO2 SMITH
7-0197

From: AIREYE/SLAR Upgrade Project Officer

To: Chief, Aviation Plans and Programs Branch

(a) Meeting between CWO2 Smith (G-EAE)/LCDR Lillie (G-OAV) of 18 March 1994

1. The HC-130H SLAR upgrade cost estimate for the FY96 Resource Change Proposal (RCP) is submitted as enclosure (1). The cost estimate has been prepared using current market costs for Commercial Off The Shelf (COTS) hardware and software whenever possible. Costs associated with the non-COTS hardware and software have also been included in the total cost estimate of the SLAR upgrades.

2. Should you have any questions concerning this effort please contact me at 7-0197.

BRAD T. SMITH

Encl: (1) Cost Estimate for the HC-130H SLAR Upgrades

HC-130H SLAR UPGRADES COST ESTIMATE

	Ea	#systems	Total $	$ FY96
Software/ NRE/ Integration	$550K	1	$550K	580
Production/ Hardware	$150K	3 sets	$450K	475
Syncronizer Replacement	$250K	3 sets	$750K	791
GSE/ Test Equipment/ Hot mock-up	$100K	1 set	$100K	105
Ground Station	$75K	2 sets	$150K	158
		TOTAL	$2.0M	2,109